

Description

MEDICAL IMAGE DIAGNOSING SUPPORT APPARATUS AND METHOD

Technical Field

The present invention relates to a medical image diagnosing support apparatus
5 and method for measuring body adipose of a subject based on a tomographic image of
the subject acquired by a medical tomographic apparatus such as an X-ray CT (computed
tomography) apparatus or an MRI (magnetic resonance imaging) apparatus. More
particularly, the present invention relates to a medical image diagnosing support
apparatus and method that can automatically separately measure subcutaneous adipose
10 and visceral adipose using information on a periphery of adipose tissue such as muscle
tissue of the subject.

Background Art

Japanese Patent Application Laid-Open No. 2002-222410 discloses an image
diagnosing apparatus that measures body adipose of a subject based on a tomographic
15 image of the subject acquired from a medical tomographic apparatus. The image
diagnosing apparatus sets a boundary between subcutaneous adipose and visceral adipose
with respect to a peripheral edge of a muscle region by a rolling ball method. This has
a problem that the subcutaneous adipose and the visceral adipose are sometimes
improperly separated depending on individual differences among subjects. The image
20 diagnosing apparatus also has a problem of an unclear image display of a measurement
result. Further, the image diagnosing apparatus extracts, as an adipose region, a region
where a CT value is within a threshold range set by an operator. This causes an
unnecessary minute adipose region such as feces remaining in intestine to be included in
the extraction region, and for precise measurement, the operator has to manually remove
25 the unnecessary region. The image diagnosing apparatus sequentially performs the
steps of extraction of a body surface region of interest, extraction of a total body adipose
region, extraction of a visceral region of interest, extraction of a visceral adipose region,
and calculation of body adipose. This has a problem that each step includes many
computations, and enhancing the speed of the processing is not considered.

Disclosure of the Invention

In order to achieve the above described problems, the present invention relates to a medical image diagnosing support apparatus comprising: a first extraction means which extracts a body region of a subject from a tomographic image of the subject
 5 acquired by a medical tomographic apparatus; a second extraction means which extracts a non-adipose region from the body region; a third extraction means which extracts a total body adipose region from the body region; a separation means which separates the total body adipose region into a visceral adipose region and a subcutaneous adipose region based on positional information of the non-adipose region; and a display control
 10 means which controls to display the tomographic image on an image display device with clear indication of the visceral adipose region and the subcutaneous adipose region.

The present invention also relates to a medical image diagnosing support method comprising: a first extraction step of extracting a body region of a subject from a tomographic image of the subject acquired by a medical tomographic apparatus; a second
 15 extraction step of extracting a non-adipose region from the body region; a third extraction step of extracting a total body adipose region from the body region; a separation step of separating the total body adipose region into a visceral adipose region and a subcutaneous adipose region based on positional information of the non-adipose region; and a display control step of controlling of displaying the tomographic image on
 20 an image display device with clear indication of the visceral adipose region and the subcutaneous adipose region.

Brief Description of the Drawings

Figure 1 is a schematic view of a configuration of a medical image diagnosing support apparatus according to an embodiment of the present invention;

25 Figure 2 is a flowchart of a first embodiment for measuring body adipose of a subject;

Figure 3 is a flowchart of body region extraction processing;

Figure 4 is a conceptual drawing for illustrating the body region extraction processing;

30 Figure 5 is a flowchart of navel region identifying processing;

Figure 6 is a conceptual drawing for illustrating the navel region identifying processing;

Figure 7 is a flowchart of visceral region extraction processing;

5 Figures 8(a), 8(b) and 8(c) are conceptual drawings for illustrating the visceral region extraction processing;

Figure 9 shows an example of a display of an error message;

Figure 10 shows an example of a display of a measurement result;

Figure 11 shows an example of a display of print processing selection;

10 Figure 12 a flowchart of a second embodiment for measuring body adipose of a subject;

Figure 13 is a conceptual drawing of an adipose region near a muscle region in the back;

Figure 14 a flowchart of image determination processing;

Figure 15 is a conceptual drawing for illustrating a search for a navel region;

15 Figure 16 is a flowchart of subcutaneous adipose region extraction processing;

Figure 17 is a conceptual drawing for illustrating the subcutaneous adipose region extraction processing;

Figure 18 a flowchart of unnecessary region removal processing;

20 Figure 19 a flowchart of a third embodiment for measuring body adipose of a subject;

Figure 20 is a flowchart of navel region removal processing;

Figure 21 is a conceptual drawing for illustrating the naval region removal processing;

25 Figure 22 is a conceptual drawing for illustrating the navel region removal processing;

Figure 23 is a flowchart of estimation of a subcutaneous adipose region;

Figure 24 is a conceptual drawing for illustrating the estimation of the subcutaneous adipose region; and

30 Figure 25 is a conceptual drawing for illustrating division of the subcutaneous adipose region and a visceral adipose region.

Best Mode for Carrying out the Invention

Now, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

Figure 1 is a schematic view of a configuration of a medical image diagnosing support apparatus according to an embodiment of the present invention. The medical image diagnosing support apparatus 10 mainly includes a central processing unit (CPU) 12 that controls operations of components, a main memory 14 in which a control program of the medical image diagnosing support apparatus 10 is stored, a data recording device 16 in which tomographic image data of a subject and an operation program, or the like are stored, a display memory 18 that temporarily stores image data for display, a display 20 that displays an image based on the image data from the display memory 18, a pointing device 22 and a pointing device controller 24 such as a mouse, a trackball, or a touch panel for operating a soft switch on the display 20, a keyboard 26 having keys or switches for setting various parameters, a network adapter 28 for connecting the medical image diagnosing support apparatus 10 to a network N such as a local area network, a telephone line, or the Internet, and a bus 30 that connects the above described components. The data recording device 16 may be a storage device such as a memory or a magnetic disk internal or external to the medical image diagnosing support apparatus 10, a device for writing and reading data in and from ejectable external media, or a device for transmitting and receiving data to and from an external storage device via a network. The medical image diagnosing support apparatus 10 is connected to an external medical tomographic apparatus 50 or an image database 60 via the network adapter 28 and the network N, and transmits and receives image data thereto and therefrom.

Figure 2 is a flowchart of a first embodiment for measuring body adipose of a subject using the medical image diagnosing support apparatus 10 configured as described above. The CPU 12 controls the medical image diagnosing support apparatus 10 according to this flowchart.

First, an ID input screen of the subject is displayed on the display 20, and an operator inputs an ID number of the subject of diagnostic processing (S201). Then, based on the input ID number of the subject, image data for body adipose measurement processing is read from the data recording device 16, the medical tomographic apparatus 50, or the image database 60 (S202). Image data acquired by a medical tomographic

apparatus such as an X-ray CT apparatus or an MRI apparatus is available, and CT image data acquired by the X-ray CT apparatus will be described by way of an example.

Next, body region extraction processing (S203), navel region identifying processing (S204), and visceral region extraction processing (S205) of the read image data are sequentially performed, and a visceral region is extracted. Then, based on the results of S204 and S205, it is determined whether the image of interest is suitable for body adipose measurement (S206). When it is determined that the image of interest is not suitable, the processing is finished. When it is determined in S206 that the image of interest is suitable, area ratios of adipose pixels are calculated (S207), and the measurement results are displayed by numeric values and an image (S208).

Now, details of the steps in Figure 2 will be described. Figure 3 is a flowchart of the body region extraction processing (S203). First, threshold processing of the read image data is performed to create a binary image (S301). For the threshold, an adipose threshold is preset so that a region to be recognized as body adipose is clearly extracted. A pixel value (a CT value) of adipose is usually in a range of -150 to -50, and thus a CT value range of adipose may be sequentially searched for from a CT image with the most frequent CT value in the range of -150 to -50 as a median value in a CT value histogram to automatically set an adipose threshold. Next, two-dimensional labeling processing of the binary image created in S301 is performed to create a label image, and as shown in Figure 4, a label region showing the largest area in the label image is extracted as a body region 401 (S302). Then, pixels having pixel values within the threshold range among pixels that form the body region 401 are extracted as adipose pixels, and "1" is stored in a position corresponding to the adipose pixels in an adipose image buffer (S303). The adipose pixels thus extracted correspond to the total body adipose including subcutaneous adipose and visceral adipose. Then, peripheral edge recognition processing is performed for each of the pixels that form the body region 401 with attention to eight pixels on a periphery of each pixel. Then, the number of pixels recognized as the peripheral edge is multiplied by the length of one side of one pixel to calculate a waist circumference at the navel (S304).

Figure 5 is a flowchart of the navel region identifying processing (S204). First, in the peripheral edge of the body region recognized in S304, normal vectors 601 are calculated at regular intervals as shown in Figure 6 (S501). Then, a navel region is

identified based on the fact that the navel region is placed in an upper side of the tomographic image, and an angle change between adjacent normal vectors 601 is significantly large in the navel region (S502).

Figure 7 is a flowchart of the visceral region extraction processing (S205).

5 First, the threshold processing of the image data in the body region 401 is performed to create a binary image (S701). The threshold is preset so that a region (hereinafter referred to as an abdominal wall muscle layer region) 801 to be recognized as a muscle tissue layer (an abdominal wall muscle layer) and a bone tissue layer in Figure 8(a) is clearly extracted. Also, a pixel value (a CT value) of the abdominal wall muscle layer
10 is usually in a range of -50 to 100, and thus a CT value range of the abdominal wall muscle layer may be sequentially searched for from the CT image with the most frequent CT value in the range of -50 to 100 as a median value in the CT value histogram to automatically set a threshold. Next, peripheral edge recognition processing of the binary image created in S701 is performed to radially set attention points on the
15 recognized peripheral edge (S702). The recognized peripheral edge is traced to extract an outline of the abdominal wall muscle layer including the whole viscus. However, actually, the abdominal wall muscle layer does not continuously surround the viscus but gaps are present in several spots, and thus for such an abdominal wall muscle layer with the gaps, the outline of the abdominal wall muscle layer including the whole viscus
20 cannot be extracted simply by tracing the peripheral edge. Thus, spaces between the attention points set in S702 are interpolated by higher order spline interpolation to interpolate the gaps in the abdominal wall muscle layer and extract an outline 802 of the visceral region as shown in Figure 8(b) (S703). Then, region extraction processing of the outline 802 using a region expansion method is performed to extract a visceral region
25 803 as shown in Figure 8(c) (S704). Next, pixels having pixel values within the adipose threshold range among pixels that form a region obtained by subtracting the abdominal wall muscle layer region 801 from the visceral region 803 are extracted as adipose pixels, and "2" is stored in a position corresponding to the adipose pixels in the adipose image buffer (S705). The adipose pixels thus extracted correspond to the visceral adipose.

30 In the determination whether the image of interest is suitable (S206), it is determined that the image of interest is suitable when the percentage of an air region in the visceral region 803 obtained in S205 is less than 60% and the navel region has been

able to be identified in S204, and the process proceeds to S207. When it is not determined that the image of interest is suitable in S206 because the image of interest is an image obtained from a site other than abdominal such as lung field, or the image is not a CT image, a message such as "The image is incorrect" is output on the display 20 as shown in Figure 9 to finish the processing.

In the calculation of the area ratios of the adipose pixels (S207), the number of pixels S corresponding to the subcutaneous adipose is calculated from the number of pixels W corresponding to the total body adipose extracted in S303 and the number of pixels V corresponding to the visceral adipose extracted in S705, and the ratio V/W between the visceral adipose and the total body adipose, the ratio S/W between the subcutaneous adipose and the total body adipose, and the ratio V/S between the visceral adipose and the subcutaneous adipose are calculated.

In the display of the measurement result (S208), as shown in Figure 10, the visceral adipose 1001 and the subcutaneous adipose 1002 are displayed on the display 20 with different colors or densities so as to be distinguishable, and the numeric values calculated in S207 are displayed. After S208, printing of the display image may be selectable as shown in Figure 11 so that the body adipose measurement result is printed and handed to the subject.

Figure 12 is a flowchart of a second embodiment for measuring body adipose of a subject using a medical image diagnosing support apparatus 10. Generally, in an abdominal tomographic image, all regions obtained by subtracting a visceral organ region such as bone, muscle and intestine, and a gas region from the tomographic image are considered as adipose regions. Thus, such subtracting processing allows the adipose region to be extracted even without threshold processing based on a CT value. In some cases, an adipose region 1301 near a muscle region in the back is improperly recognized to reduce measurement accuracy as shown in Figure 13. Thus, in the second embodiment, a subcutaneous adipose region is recognized based on positional information of a muscle region in the abdominal wall layer to allow the adipose region in the back to be precisely recognized for more precise measurement of the body adipose.

Input of a subject ID (S1201), image data reading (S1202), and body region extraction processing (S1203) in Figure 12 are the same as in S201, S202 and S203 in Figure 2. Then, it is determined whether the image of interest is suitable for body

adipose measurement (S1204). When it is determined that the image of interest is not suitable, the process is finished. When it is determined in S1204 that the image of interest is suitable, subcutaneous adipose region extraction processing (S1205) and unnecessary adipose region removal processing (S1206) are performed to extract the adipose region. Calculation of area ratios of adipose pixels (S1207) and a display of measurement results (S1208) are the same as in S207 and S208 in Figure 2.

Figure 14 is a flowchart of image determination processing (S1204). First, as shown in Figure 15, the barycenter 1501 of the body region extracted in S1203 is calculated (S1401). Then, an ellipse 1502 is set so as to be tangent to a peripheral edge on the abdominal side of the body region (S1402). Then, a navel region is searched for based on the area of a region between the peripheral edge on the abdominal side of the body region and the external tangent ellipse 1502 with attention to a range of an angle θ in a predetermined direction around the barycenter 1501 (S1403). Then, threshold processing is performed using a threshold preset so as to allow recognition of air to recognize an air region in the body region (S1404). Then, only when the navel region is identified in S1403, and the air region recognized in S1404 is within a predetermined percentage in the body region, it is determined that the image of interest is suitable for the body adipose measurement (S1405).

Figure 16 is a flowchart of the subcutaneous adipose region extraction processing (S1205). First, a preset threshold is used to perform threshold processing in order to recognize a muscle region 1701 in the body region extracted in S1203 in Figure 17 (S1601). Then, the body region is divided into regions with angles θ_1 , θ_2 and θ_3 around the barycenter 1501 of the body region calculated in S1401, and ellipses 1702, 1703 and 1704 which are tangent to peripheral edges of the regions are set (S1602). Then, for each preset smaller region 1705, an external tangent line is contracted in the direction of the barycenter 1501 with the ellipses 1702, 1703 and 1704 as base points, and the contraction of the line is stopped when the line is tangent to the muscle region 1701, thereby obtaining an external tangent line 1706 of the muscle region 1701 (S1603). The region between the external tangent line 1706 and the ellipses 1702, 1703 and 1704 is the subcutaneous adipose region.

Figure 18 is a flowchart of the unnecessary region removal processing (S1206). The region obtained by removing the subcutaneous adipose region recognized in S1205

from the total body adipose region recognized in S1203 (S303) is a visceral adipose candidate region. A density gradient value of the CT value is calculated in the visceral adipose candidate region (S1801). Then, threshold processing of the density gradient value is performed at an upper limit value and a lower limit value to extract a region with large dispersion in the CT values such as feces remaining in intestine (S1802). Then, a visceral adipose region is extracted by removing the muscle region 1701 extracted in S1601 and the region with large dispersion in the CT values extracted in S1802 from the visceral adipose candidate region, and the number of pixels in the visceral adipose region is counted to calculate the number of pixels of visceral adipose.

Figure 19 is a flowchart of a third embodiment for measuring body adipose of a subject using a medical image diagnosing support apparatus 10. Image input is performed as in S201 and S202 in Figure 2 (S1901), body region extraction processing is performed like the processing in S203 in Figure 2 (S1902), and a navel region is identified like the processing in S204 in Figure 2 or the processing in S1403 in Figure 14 (S1903). Then, a preset region is removed from the body region peripheral edge recognized in S1902, and thus a region including an epidermal region is removed from a region for body adipose measurement (S1904). Then, extraction processing of a muscle and bone region is performed like the processing in S701 in Figure 7 (S1905). Then, navel region removal processing (S1906) and estimation of the subcutaneous adipose region (S1907) are sequentially performed. Then, adipose region dividing processing is performed like the processing in S205 in Figure 7 or the processing in S1205 in Figure 12 (S1908), and result output (S1909) is performed as in S207 and 208 in Figure 2.

Figure 20 is a flowchart of the navel region removal processing (S1906). First, as shown in figure 21, on a body region peripheral edge 2101 recognized in S1902 and a peripheral edge 2103 of the muscle and bone region 2102 recognized in S1905, attention points 2105 and 2106 are radially set so as to include the navel region identified in S1903 around the barycenter 2104 of the body region to calculate an average distance between the attention points (S2001). Then, as shown in Figure 22, a circular region with the average distance calculated in S2001 as a radius is set as a region of interest 2201 in the navel region identified in S1903 (S2002). At this time, a region that does not overlap the body region is removed. Then, the muscle and bone region in the region of interest 2201 is removed (S2003).

Figure 23 is a flowchart of the estimation of the subcutaneous adipose region (S1907). First, an attention point is set on a middle point between portions of the muscle and bone region remaining without being removed in S2003 (S2301). Then, a distance value between the attention point and an attention point on the body region peripheral edge is calculated (S2302), and as shown in Figure 24, a circular region with the distance value calculated in S2302 as a radius is set as a region of interest 2401 (S2303). At this time, based on information on a periphery of the attention point to which attention is paid, a threshold is set to correct the distance value. A region that does not overlap the body region is removed. Then, the muscle and bone region in the region of interest 2401 is removed to estimate the subcutaneous adipose region (S2304).

In the adipose region dividing processing (S1908), a boundary line 2501 is set as shown in Figure 25, and the adipose region is divided on the outside and the inside of the boundary line 2501 into the subcutaneous adipose region and the visceral adipose region.

In the above described embodiment, the example of performing the body adipose measurement processing using the CT image data acquired by the X-ray CT apparatus has been described. When MRI image data acquired by an MRI apparatus is used, the MRI image data has no measure such as the CT value, and thus for example, a dynamic range of the MRI data is adjusted to a dynamic range of the CT image data. Data processing thereafter may be performed as in the case of using the CT image data.

Industrial Applicability

As described above, according to the present invention, a threshold range of adipose pixels that differs depending on subjects may be easily calculated, and region extraction can be automatically performed based on information on a periphery of a site including the adipose pixels to eliminate the need for a manual operation by an operator, thereby improving operability and body adipose measurement accuracy. Further, a clear image display of a measurement result may be obtained.